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APPLICANT : DOWA MINING CO LTD;

INVENTOR : KOSAKA MITSUTERU;

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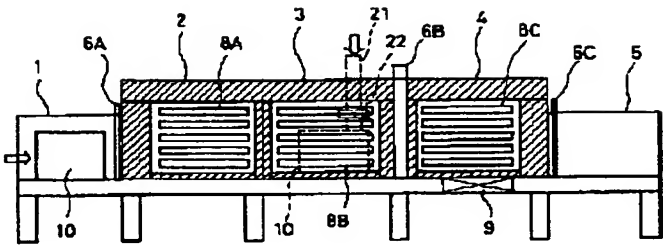
TITLE : MANUFACTURE OF METAL-CERAMIC COMPLEX MEMBER, MANUFACTURING APPARATUS AND MOLD FOR MANUFACTURING



ABSTRACT : PROBLEM TO BE SOLVED: To increase the joining strength between a metal and a ceramic and to improve the quality.

SOLUTION: In a manufacturing apparatus of a metal-ceramic complex member, in which the metal is joined on the surface of the ceramic member by holding the ceramic member in a mold, pouring molten metal to be joined and cooling and solidifying, an atmosphere replacing part 1, in which oxygen concn. is made to a prescribed value or lower by replacing the atmosphere in the mold in the state of holding the ceramic member in the mold, a preheating part 2 for preheating the mold, a molten metal pouring part 3, in which the molten metal is poured into the mold while holding the temp. in the mold to the molten metal pouring temp., a cooling joining part 4, in which the metal is joined with the surface of the ceramic member by lowering the temp. in the mold to the joining temp. at the start of solidification of the molten metal and a slow cooling part 5 for slowly cooling the mold.

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CLAIMS

[Claim(s)]
[Claim 1] By holding a ceramic member in mold, pouring in and carrying out cooling solidification of the molten metal of the metal which should be joined into this mold so that the front face of said ceramic member may be contacted Where a ceramic member is held in said mold according to the direct junction force in the mutual interface of the ceramics and a metal in the manufacture approach of the metal-ceramic compound member which joins a metal to the front face of a ceramic member The mold ambient atmosphere permutation process which permutes the ambient atmosphere in said mold and makes an oxygen density below a predetermined value, The preheating process which heats said mold beforehand after this process, and the teeming process which maintains the temperature in said mold to pouring temperature after this process, and carries out teeming of the molten metal of said metal into this mold so that the inside of this mold may be filled, The junction process which it lowers [process] to the virtual junction temperature with which the molten metal of said metal begins to solidify the temperature in said mold, and a junction operation is demonstrated after this process, and joins a metal to the front face of said ceramic member, The manufacture approach of the metal-ceramic compound member characterized by having the annealing process which anneals said mold after this process.
[Claim 2] The molten metal inlet which introduces a metal molten metal in this mold as said mold at said teeming process, It has the joint which secures a predetermined opening between the front face of this ceramic member, and a mold wall while holding said ceramic member. And teeming is performed using what has the narrow section which removes the oxide skin formed in said metal molten metal front face in the middle of the path to a joint from said molten metal inlet. The manufacture approach of the metal-ceramic compound member according to claim 1 characterized by supplying the metal molten metal after the oxide skin was removed by the narrow section at said joint.
[Claim 3] The manufacture approach of the metal-ceramic compound member according to claim 1 or 2 characterized by making an oxygen density 1% or less in said mold ambient atmosphere permutation process.
[Claim 4] The manufacture approach of the metal-ceramic compound member according to claim 1 to 3 characterized by making pouring temperature into 700-800 degrees C in said teeming process.
[Claim 5] The manufacture approach of the metal-ceramic compound member according to claim 1 to 4 characterized by making virtual junction temperature into 550-750 degrees C in said junction process.
[Claim 6] The manufacture approach of the metal-ceramic compound member according to claim 1 to 5 characterized by performing actuation which lowers the temperature in said mold to virtual junction temperature in said junction process so that it may turn to the upper part from said mold pars basilaris ossis occipitalis and temperature may fall gradually.
[Claim 7] The manufacture approach of the metal-ceramic compound member according to claim 1 to 6 characterized by said metal being the alloy which uses aluminum or aluminum as a principal component.
[Claim 8] The manufacture approach of a metal-ceramic compound member according to claim 1 to 7 that said ceramic member is characterized by being the oxide of aluminum, a nitride, carbide, the oxide of silicon, a nitride, or carbide.
[Claim 9] By holding a ceramic member in mold, pouring in and carrying out cooling solidification of the molten metal of the metal which should be joined into this mold so that the front face of said ceramic member may be contacted In the manufacturing installation of the metal-ceramic compound member which joins a metal to the front face of a ceramic member according to the direct junction force in the mutual interface of the

ceramics and a metal The mold ambient atmosphere permutation section which has the ambient atmosphere permutation means which permutes the ambient atmosphere in said mold in said mold where a ceramic member is held, and makes an oxygen density below a predetermined value, The preheating section which has a temperature control means to heat beforehand the mold after performing a mold ambient atmosphere permutation in this mold ambient atmosphere permutation section, A temperature control means to maintain the temperature in the mold which carried out the preheating in this preheating section to pouring temperature, The teeming section which has the teeming means which carries out teeming of said metal molten metal into this mold so that the inside of this mold may be filled, The manufacturing installation of the metal-ceramic compound member characterized by having the cooling joint which it lowers [joint] to the virtual junction temperature with which said metal molten metal begins to solidify the temperature in the mold by which teeming was carried out in this teeming section, and a junction operation is demonstrated, and joins a metal to said ceramics, and the annealing section which anneals said mold.

[Claim 10] The manufacturing installation of the metal-ceramic compound member according to claim 9 to which said mold ambient atmosphere permutation section is characterized by permuting the ambient atmosphere in said mold by the inert gas ambient atmosphere.

[Claim 11] The manufacturing installation of the metal-ceramic compound member according to claim 9 or 10 characterized by being that in which said cooling section has a heating means to heat said mold from the side, and a cooling means to cool said mold from a pars basilaris ossis occipitalis.

[Claim 12] By holding a ceramic member in mold, pouring in and carrying out cooling solidification of the molten metal of the metal which should be joined into this mold so that the front face of said ceramic member may be contacted In the mold for manufacture used for the manufacture approach of the metal-ceramic compound member which joins a metal to the front face of a ceramic member according to the direct junction force in the mutual interface of the ceramics and a metal The molten metal inlet which introduces a metal molten metal in mold, and the joint which secures a predetermined opening between the front face of this ceramic member, and a mold wall while holding said ceramic member, The molten metal path which leads a metal molten metal to a joint from said molten metal inlet, and the narrow section which removes the oxide skin which was prepared in one location of these molten metal paths, and was formed in the metal molten metal fron face, When it has the gas drainage hole prepared in said joint, a metal molten metal is introduced in mold from said molten metal inlet and said joint is supplied, Mold for manufacture of the metal-ceramic compound member characterized by constituting said joint and a molten metal path so that this metal molten metal may fill the inside of this mold.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the mold for manufacture at the manufacture approach of a metal-ceramic compound member that the ceramics and a metal were firmly joined by the direct junction force in a mutual interface, a manufacturing installation, and a list.
[0002]
[Description of the Prior Art] the chemical stability of the ceramics, high-melting, insulation, a high degree of hardness, and the metal-ceramic compound member that was comparatively alike and employed properties, such as properties, such as high thermal conductivity, metaled high intensity, high toughness and easy-workability, and conductivity, efficiently are widely used for an automobile, an electronic instrument, etc., and the metal-ceramic compound substrate and package the rotor for automobile turbochargers and for large power electronic device mounting are mentioned as the typical example.
[0003] as the main manufacture approaches of the above-mentioned metal-ceramic compound member -- adhesion, plating, metallizing, thermal spraying, an insert, a brazing-and-soldering method; and DBC -- DBC using the problem on cost to an alumina substrate about a metal-ceramic compound substrate in recent years although law is well-known -- most metal-ceramic compound substrates are manufactured by law or the metal activity wax conjugation method using an alumimium nitride substrate.
[0004] however, DBC which joins a copper plate directly as an approach of joining a metal to an alumina substrate directly in a conventional method -- although law was well-known, the approach of joining aluminum directly was not learned until now.
[0005] These people considered as the equipment which joins the aluminum as a metal plate to a ceramic member directly previously, and proposed "the manufacturing installation of a metal-ceramic compound member" to JP,8-198629,A.
[0006] A conveyance means for this equipment to supply a ceramic member continuously, The preheating section which heats the conveyed ceramic member beforehand, and the joint which is made to pass through the inside of the metal molten metal in crucible the ceramic member by which the preheating was carried out, and joins a metal to a part of perimeter side [at least] of a ceramic member, It is possible to manufacture the metal-ceramic compound member which has the property which anneals the joined this ceramic member, was made to solidify a metal, makes the cooling section used as a metal-ceramic compound member with the principal part, and was excellent in large quantities.
[0007]
[Problem(s) to be Solved by the Invention] By the way, although the case where the request which manages the homogeneity of the thickness of this sheet metal very severely was made recently was seen when a sheet metal-like metal was joined to a ceramic member, to such a request, there was a case where it could not necessarily respond fully, with the above-mentioned equipment. Moreover, although development of the ceramic compound substrate which raises a heat dissipation property by changing the thickness of a circuit side and a heat sinking plane was also made, in the above-mentioned continuation manufacturing installation, drawing out the compound substrate after junction straightly needed the advanced technique.
[0008] That is, the above-mentioned conventional equipment is structure which supplies a ceramic member horizontally (longitudinal direction) continuously, and is passed in crucible. Therefore, when joining a metal to the 2nd page of the front flesh side of a tabular ceramic member, it moves, while a metal molten metal contacts

the member both sides, and joins in the cooling section.
[0009] However, although the pinch roll had pulled the tip horizontally when it was the ceramic compound substrate with which the thickness of the vertical side of the joined metal differs, it became clear that there may be an inclination at which it turns in the thick direction of the joined metal side, and the advanced technique was needed for performing continuous manufacture smoothly by this.
[0010] This invention is made under an above-mentioned background, and aims at providing with the mold for manufacture the manufacture approach for making it possible to manufacture the various metal-ceramic compound members which have the especially excellent junction property by low cost, a manufacturing installation, and a list.
[0011]
[Means for Solving the Problem] The manufacture approach of invention of claim 1 by holding a ceramic member in mold, pouring in and carrying out cooling solidification of the molten metal of the metal which should be joined into this mold so that the front face of said ceramic member may be contacted Where a ceramic member is held in mold according to the direct junction force in the mutual interface of the ceramics and a metal in the manufacture approach of the metal-ceramic compound member which joins a metal to the front face of a ceramic member The mold ambient atmosphere permutation process which permutes the ambient atmosphere in mold and makes an oxygen density below a predetermined value, The preheating process which heats mold beforehand after this process, and the teeming process which maintains the temperature in mold to pouring temperature after this process, and carries out teeming of the metaled molten metal into mold so that the inside of this mold may be filled, It is characterized by having lowered to the virtual junction temperature with which a metaled molten metal begins to solidify the temperature in mold, and a junction operation is demonstrated after this process, and having the junction process which joins a metal to the front face of a ceramic member, and the annealing process which anneals mold after this process.
[0012] The manufacture approach of invention of claim 2 is said teeming process in claim 1. As said mold, it has the molten metal inlet which introduces a metal molten metal in this mold, and the joint which secures a predetermined opening between the front face of a ceramic member, and a mold wall while holding a ceramic member. And it is characterized by supplying the metal molten metal after it performed teeming using what has the narrow section which removes the oxide skin formed in the metal molten metal front face in the middle of the path to a joint from a molten metal inlet and the oxide skin was removed by said joint by the narrow section.

[0013] The manufacture approach of invention of claim 3 is characterized by making an oxygen density 1% or less at said mold ambient atmosphere permutation process in claims 1 or 2.
[0014] The manufacture approach of invention of claim 4 is characterized by the pouring temperature in said teeming process being 700-800 degrees C in either of claims 1-3.
[0015] The manufacture approach of invention of claim 5 is characterized by the virtual junction temperature in said junction process being 550-750 degrees C in either of claims 1-4.
[0016] The manufacture approach of invention of claim 6 is characterized by performing actuation which lowers the temperature in mold to virtual junction temperature in said junction process so that it may turn to the upper part from a mold pars basilaris ossis occipitalis and temperature may fall gradually in either of claims 1-5.

[0017] The manufacture approach of invention of claim 7 is characterized by being the alloy with which said metal uses aluminum or aluminum as a principal component in either of claims 1-6.
[0018] The manufacture approach of invention of claim 8 is characterized by said ceramic member being the oxide of aluminum, a nitride, carbide, the oxide of silicon, a nitride, or carbide in either of claims 1-7.
[0019] By the manufacturing installation of invention of claim 9 holding a ceramic member in mold, and pouring in and carrying out cooling solidification of the molten metal of the metal which should be joined into this mold so that the front face of said ceramic member may be contacted In the manufacturing installation of the metal-ceramic compound member which joins a metal to the front face of a ceramic member according to the direct junction force in the mutual interface of the ceramics and a metal The mold ambient atmosphere permutation section which has the ambient atmosphere permutation means which permutes the ambient atmosphere in mold in mold where a ceramic member is held, and makes an oxygen density below a predetermined value, The preheating section which has a temperature control means to heat beforehand the

mold after performing a mold ambient atmosphere permutation in this mold ambient atmosphere permutation section, The teeming section which has the teeming means which carries out teeming of the metal molten metal into a temperature control means to maintain the temperature in the mold which carried out the preheating in this preheating section to pouring temperature, and mold so that the inside of this mold may be filled, It is characterized by having the cooling joint which it lowers [joint] to the virtual junction temperature with which a metal molten metal begins to solidify the temperature in the mold by which teeming was carried out in this teeming section, and a junction operation is demonstrated, and joins a metal to the ceramics, and the annealing section which anneals said mold.

[0020] The manufacturing installation of invention of claim 10 is characterized by said mold ambient atmosphere permutation section permuting the ambient atmosphere in mold by the inert gas ambient atmosphere in claim 9.

[0021] The manufacturing installation of invention of claim 11 is characterized by being that in which said cooling section has a heating means to heat mold from the side, and a cooling means to cool mold from a pars basilaris ossis occipitalis in claims 9 or 10.

[0022] The mold for manufacture of invention of claim 12 by holding a ceramic member in mold, pouring in and carrying out cooling solidification of the molten metal of the metal which should be joined into this mold so that the front face of said ceramic member may be contacted In the mold for manufacture used for the manufacture approach of the metal-ceramic compound member which joins a metal to the front face of a ceramic member according to the direct junction force in the mutual interface of the ceramics and a metal The molten metal inlet which introduces a metal molten metal in mold, and the joint which secures a predetermined opening between the front face of this ceramic member, and a mold wall while holding said ceramic member, The molten metal path which leads a metal molten metal to a joint from said molten metal inlet, and the narrow section which removes the oxide skin which was prepared in one location of these molten metal paths, and was formed in the metal molten metal front face, When it has the gas drainage hole prepared in said joint, a metal molten metal is introduced in mold from said molten metal inlet and said joint is supplied, it is characterized by constituting said joint and a molten metal path so that this metal molten metal may fill the inside of this mold.

[0023] According to the above-mentioned configuration, the mold ambient atmosphere permutation process which permutes the ambient atmosphere in mold in mold where a ceramic member is held, and makes an oxygen density below a predetermined value is performed. Next, perform the preheating process which heats mold beforehand and then the temperature in mold is maintained to pouring temperature. The teeming process which carries out teeming so that a metaled molten metal may be moved towards the side else from 1 side into mold, a metal molten metal contacting a ceramic front face and the inside of mold may be filled one by one is performed. Next, by lowering to the virtual junction temperature with which a metaled molten metal begins to solidify the temperature in mold, and a junction operation is demonstrated, performing the junction process which joins a metal to the front face of a ceramic member, and having been made to perform the annealing process which anneals mold next While being able to strengthen extremely the direct junction force in the interface of the ceramics and a metal for example, like [in the case of joining the metallic thin plate as a circuit side, and the metallic thin plate as a heat sinking plane to both sides of a ceramic substrate] Also when joining the metallic thin plate with which thickness differs mutually to both sides, the metallic thin plate of highly precise and uniform thickness can be easily joined by making precision of mold suitable. And in a preheating process, a teeming process, and a junction process, since he is trying to set it as suitable temperature respectively, there is also no possibility of excessive thermal stress not joining a ceramic member, therefore damaging with thermal stress.

[0024] Furthermore, it has as mold the molten metal inlet which introduces a metal molten metal in mold, and the joint which secures a predetermined opening between the front face of a ceramic member, and a mold wall while holding a ceramic member. It is made to perform a teeming process using what has the narrow section which removes the oxide skin formed in the location of either of the paths to a joint from a molten metal inlet on the metal molten metal front face. By supplying only the pure metal molten metal from which the oxide film was removed to a joint, it makes it possible to acquire the firmer junction force.

[0025] Even if this invention contacts a metal molten metal on a ceramic front face, the junction force is based on discovery by this invention persons that the junction force is acquired, when it is made to contact under specific conditions and solidifies to the conventional common sense of not being obtained. Although not yet

solved fully about the mechanism from which this junction force is acquired, the above-mentioned specific conditions are acquired by trial and error by this invention persons.
[0026] Namely, advantageous, when acquiring the junction force with the firm one where the oxygen density of the ambient atmosphere of the perimeter is possible as low as a joint in the case of junction, It is advantageous, when acquiring the junction force with that it is advantageous to make a ceramic front face and a metal molten metal displaced relatively, to contact them as both are rubbed, and to make it join when acquiring the firmer junction force, and firm [as for the metal molten metal to contact] the oxide skin being removed etc.
[0027] As a metal used by this invention, the alloy which uses aluminum or aluminum as a principal component can be used. Moreover, the oxide of aluminum or silicon, a nitride, carbide, etc. can be used as a ceramic member used by this invention.
[0028] according to such combination -- both sides of for example, a ceramic substrate -- a circuit -- a field -- a metallic thin plate -- a heat sinking plane -- when the substrate for power modules which joined the metallic thin plate is constituted, the differential thermal expansion of the aluminum and the ceramic substrate by generation of heat of a power module is comparatively large, but since the reinforcement of aluminum is low, what has few junction degradation by the heat expansion difference can be obtained.
[0029]
[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained based on a drawing. Drawing in which drawing 1 shows the configuration of the manufacturing installation of a metal-ceramic compound member, drawing 2 - drawing 6 are the block diagrams of mold, and the decomposition top view of the mold which looked at drawing 2 in the perspective view of the mold for manufacture, and looked at drawing 3 in the direction of an III-III view of drawing 2 , and drawing 4 are [the V-V view sectional view of drawing 2 and drawing 6 of the IV-IV view Fig. of drawing 2 R> 2 and drawing 5] the VI-VI view sectional views of drawing 2 .
[0030] This manufacturing installation manufactures a metal-ceramic compound member by holding ceramic substrate K [referring to [drawing 3 and] drawing 6 (b)] inside this mold 10, and contacting a metal molten metal to that perimeter using the mold 10 of a special configuration. The ambient atmosphere permutation section 1 to which this manufacturing installation adjusts the ambient atmosphere in mold 10 to the inert gas ambient atmosphere conditions of 1% or less of oxygen densities as shown in drawing 1 (ambient atmosphere permutation means), The preheating section 2 which heats beforehand the mold 10 after permuting an ambient atmosphere in the ambient atmosphere permutation section 1, The temperature in the mold 10 which carried out the preheating in this preheating section 2 is maintained to pouring temperature. In mold 10 in the condition a metal molten metal The teeming section 3 which carries out teeming so that it may move towards the side else from 1 side and the inside of mold may be filled one by one, a metal molten metal contacting the front face of a ceramic member, It consists of a cooling joint 4 which it lowers [joint] to the virtual junction temperature with which a metal molten metal begins to solidify the temperature in the mold 10 by which teeming was carried out in this teeming section 3, and a junction operation is demonstrated, and joins a metal to the ceramics, and the annealing section 5 which anneals said mold 10.
[0031] These ambient atmosphere permutation section 1, the preheating section 2, the teeming section 3, the cooling joint 4, and the annealing section 5 are horizontally located in a line with the serial, and the shutters 6A, 6B, and 6C for electric shielding are formed between the cooling section 4 and the annealing section 5 between the teeming section 3 and the cooling section 4 between the ambient atmosphere permutation section 1 and the preheating section 2. Moreover, in the side attachment wall of the preheating section 2, the teeming section 3, and the cooling section 4, the heaters 8A, 8B, and 8C as a heating means and a temperature control means are formed, and the temperature of the mold 10 held indoors can be appropriately controlled now on it. Especially, the water cooled jacket 9 as a cooling means is arranged on the cooling joint 5 so that mold 10 can be cooled from a pars basilaris ossis occipitalis. In addition, in the teeming section 3 of drawing 1 , it is linear DOMOTA which is shown with the sign 21 attached in mold 10, and 22 is a piston made from a graphite. These are equivalent to a teeming means.
[0032] Next, the mold 10 produced with the graphite is explained. The mold 10 used here makes mold plate 10B of the mold plates 10A and 10A on a side front and a background, and a center three-sheet doubling, joins together, and enables it to make the circuit board (metal-ceramic compound member) of four sheets at once, as shown in drawing 2 and drawing 3 . Drawing 4 shows the configuration of the internal surface of mold plate

10A on a side front and a background, and drawing 5 shows the configuration of both the wall surfaces of central mold plate 10B.

[0033] These mold plates 10A and 10B have the hollows 11A, 11B, 13A, 13B, 14A, and 14B of a predetermined configuration, and form the impregnation cylinder fixed part 11 as a molten metal inlet, the molten metal installation path 13, and the joint 14 by being combined as mold 10. The molten metal impregnation cylinder fixed part 11 is arranged in the center section of mold 10, the molten metal installation path 13 is horizontally developed so that it may branch from the lower part, and each joint 14 is formed so that it may be open for free passage at the tip of each molten metal installation path 13. The space as a joint 14 is formed in bilateral symmetry two pieces on both sides of the molten metal impregnation cylinder fixed part 11 while it is formed in front flesh-side both sides of central mold plate 10B. Therefore, it is by four all.

[0034] Moreover, the narrow section 12 which is located in the boundary of the molten metal impregnation cylinder fixed part 11 and the molten metal installation path 13, and opens both for free passage is formed in the mold 10 which consists of three mold plates 10A, 10A, and 10B, the crevice 16 for ceramic member immobilization is formed in it in the form where a central field laps with a joint 14, and the gas drainage hole 15 is formed in it so that it may be open for free passage in the upper part of a joint 14. The relation between the crevice 16 for ceramic member immobilization and a joint 14 is the internal surface of a joint 14, and the relation which can secure the predetermined opening 29 between the ceramic members K, when mold 10 is closed where the ceramic member K is inserted in the crevice 16 for ceramic member immobilization as shown in drawing 6 (b).

[0035] Moreover, the narrow section 12 is a part which removes the oxide skin of the metal molten metal front face poured in from the molten metal impregnation cylinder fixed part (equivalent to a molten metal inlet) 11, and is formed in the aperture (for example, 1mm or less, preferably 0.8mm or less) of extent which does not allow passage of an oxide skin. The metal molten metal after the oxide skin was removed by the narrow section 12 goes into the perpendicular space of the molten metal installation path 13, is introduced into the pars basilaris ossis occipitalis of a joint 14 through the level space of the molten metal installation path 13 from there, moves and goes toward the upper part from the pars basilaris ossis occipitalis of a joint 14, and contacts the front face of the ceramic member K held in the crevice 16 for ceramic member immobilization in the meantime. Therefore, after being injected into the molten metal impregnation cylinder fixed part 11, once a metal molten metal falls caudad, the path of a molten metal is constituted, moving up so that it may contact and go to the ceramic member K.

[0036] In addition, the concave heights 19A and 19B which fit in in case it joins together mutually, and position the mold plates 10A and 10A and both 10B are formed in the periphery section of the mold plates 10A, 10A, and 10B.

[0037] Next, how to make the target compound member using above-mentioned mold 10 and an above-mentioned manufacturing installation is explained. Here, the mold 10 which unified the mold plates 10A and 10A of a front flesh side by coalescing in central mold plate 10B by preparing four 62mmx112mmx0.635mm alumina-ceramics substrates, and inserting these substrates K in the crevice 16 for ceramic member immobilization of the mold plates 10A and 10B of a front flesh side as shown in drawing 3 is first made as a ceramic member K. Subsequently, the oxygen density in mold 10 is preferably set to 0-500 ppm 1% or less by installing this mold 10 in the ambient atmosphere permutation section 1, and making nitrogen gas flow in the furnace of the ambient atmosphere permutation section 1 (ambient atmosphere permutation process).

[0038] Subsequently, mold 10 is moved to the preheating section 2, and the temperature up of the mold 10 is carried out from a room temperature to 800 degrees C by heater 8A in this preheating section 2 in 1 hour (beforehand a heat process degree). in this case, the ceramic member K in mold 10 does not break -- as -- a temperature up -- it carries out -- it can kick, and if it is **, there is nothing.

[0039] Subsequently, the mold 10 which carried out the preheating is moved to the impregnation section 3, and the piston 22 made from a graphite and linear DOMOTA 11 are set to the molten metal impregnation cylinder fixed part 11 of the upper part of mold 10. after [and] breaking ********** of aluminum by pushing in an aluminum molten metal in mold 10 (pushing force being 70kgMAX(s)), and passing the narrow section 12 by pressurizing the piston 22 made from a graphite by linear DOMOTA 21, where an aluminum molten metal (metal molten metal) is poured into mold 10 -- pure -- only a **** aluminum molten metal is supplied to the molten metal installation path 13 below the narrow section 12. It is good to pour in an aluminum molten metal

into mold 1 so that an aluminum molten metal may move at the rate of 1000 or less mm/min in a ceramic substrate top.

[0040] Thus, if an aluminum molten metal is stuffed into the molten metal installation path 13, an aluminum molten metal is introduced into the pars basilaris ossis occipitalis of a joint 14 from the molten metal installation path 13, it will go up, and it will go so that it may face across both sides of the ceramic substrate fixed to the crevice 16 for ceramic member ****, and will reach the upper limit (molten metal reservoir section) of a joint 14 (teeming process). Actuation of linear DOMOTA 21 is stopped in the place to which the part of these escaped from and came out of the gas drainage hole 15.

[0041] In the case of this teeming process, whenever [furnace temperature / of the teeming section 3] is adjusted to 700-850 degrees C by heater 8B. This is because fluidity nature worsens, it will react with mold ****** if it is 850 degrees C or more conversely, and a mold detached building worsens below 700 degrees C since the melting point of aluminum is 660 degrees C.

[0042] If the above-mentioned teeming process is completed, mold 10 will be moved to the cooling joint 4, it cools with the lower water cooled jacket 9, heating by heater 8C of both walls in the cooling joint 4, and applying a 3-5 degrees C [per cm] temperature gradient in the height direction from the lower part of mold 10, it will cool slowly over 30 minutes to 600 degrees C, and aluminum will be joined to a ceramic substrate (junction process).

[0043] Next, after taking out mold 10 in the annealing section 5 and carrying out **** (annealing process) to near the room temperature temperature, mold 10 is taken out outside, the aluminum alumina-ceramics compound member of four sheets is taken out from mold 10, and an activity is completed.

[0044] Thus, the obtained aluminum alumina-ceramics compound member showed the uniform field which does not have a shrinkage cavity etc. in an aluminum front face.

[0045] In addition, also when same processing was performed using an alumimium nitride member and a silicon nitride member as a ceramic member, the compound member which shows the uniform field which does not have a shrinkage cavity etc. similarly was obtained.

[0046]

[Effect of the Invention] As explained above, while being able to strengthen extremely the direct junction force in the interface of the ceramics and a metal according to this invention, a compound substrate without a shrinkage cavity etc. can be manufactured with the sufficient yield. Also when joining the metallic thin plate with which thickness differs mutually to both sides like [in the case of following, for example, joining the metallic thin plate as a circuit side, and the metallic thin plate as a heat sinking plane to both sides of a ceramic substrate], the metallic thin plate of highly precise and uniform thickness can be easily joined by making precision of mold suitable. Moreover, by setting mold as suitable temperature in each process, such as a preheating process, and a teeming process, a junction process, it can avoid that excessive thermal stress joins a ceramic member, and a possibility of damaging with thermal stress can be abolished. Moreover, the narrow section which removes an oxide skin is prepared in the interior of mold, and if only the pure metal molten metal from which the oxide film was removed is supplied to a joint, the firmer junction force can be acquired. Therefore, it becomes possible to manufacture the various metal-ceramic compound members which have the outstanding junction property to low cost.

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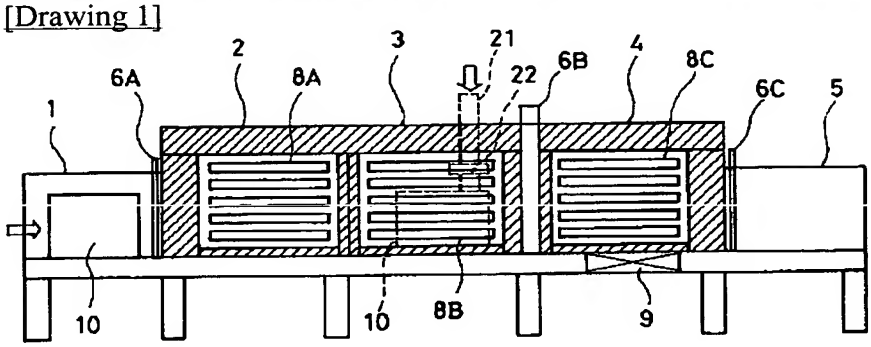
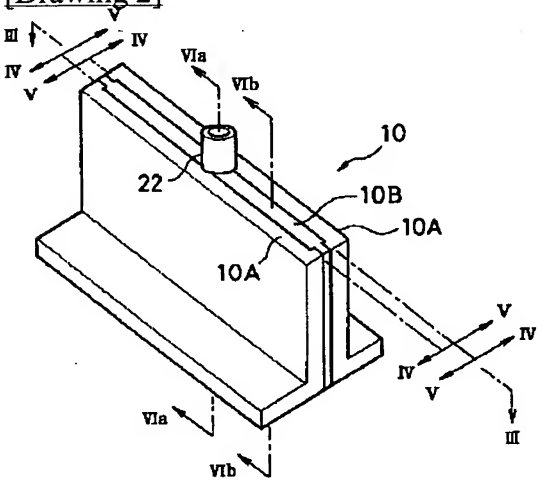
DRAWINGS

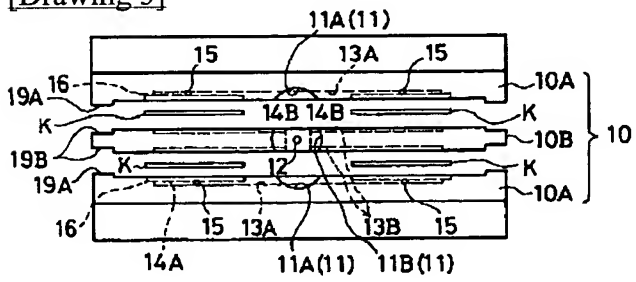
[Drawing 1]



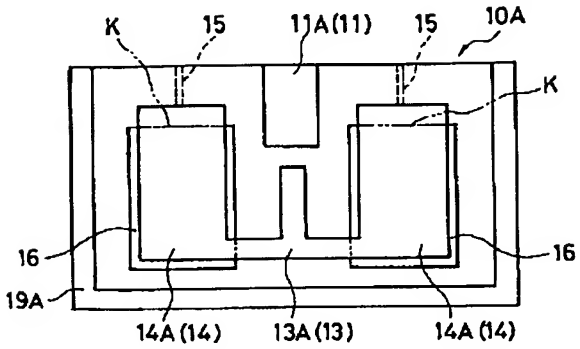
[Drawing 2]



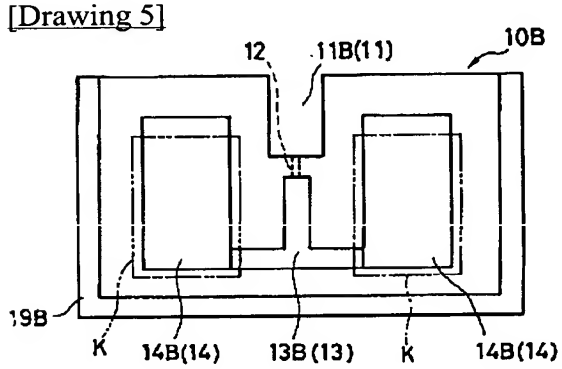
[Drawing 3]



[Drawing 4]



[Drawing 5]



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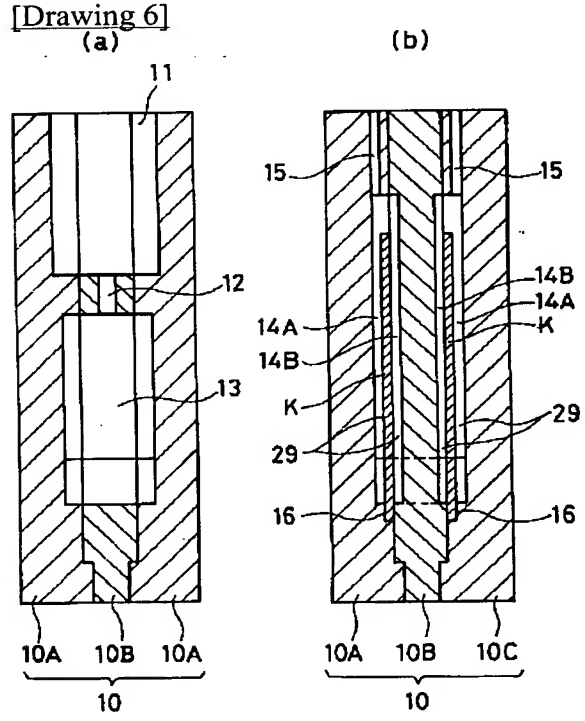

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(71)出願人　000224798
同和鉱業株式会社
東京都千代田区丸の内１丁目８番２号

(72)発明者　風呂　正博
東京都千代田区丸の内一丁目８番２号　同和鉱業株式会社内

(72)発明者　小坂　満光
東京都千代田区丸の内一丁目８番２号　同和鉱業株式会社内

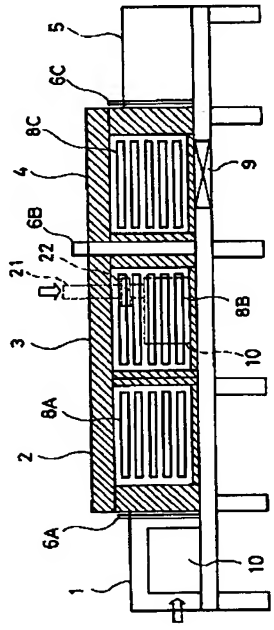
(74)代理人　弁理士　阿仁屋　節雄　（外２名）

(54)【発明の名称】　金属ーセラミックス複合部材の製造方法、製造装置、及び製造用鋳型

(57)【要約】

【課題】　金属とセラミックスの接合強度を高めかつ品質の向上を図る。

【解決手段】　鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を注入して冷却固化させることにより、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造装置において、鋳型中にセラミックス部材を保持した状態で鋳型内の雰囲気を置換して酸素濃度を所定値以下にする雰囲気置換部１と、鋳型を予熱する予熱部２、鋳型内の温度を注湯温度に維持し鋳型内に金属溶湯注入する注湯部３と、鋳型内の温度を金属の溶湯が凝固し始める接合温度まで下げてセラミックス部材の表面に金属を接合させる冷却接合部４と、鋳型を徐冷する徐冷部５とを備える。



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【特許請求の範囲】

【請求項１】　鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を前記セラミックス部材の表面に接触するように注入して冷却固化させることにより、セラミックスと金属との互いの界面での直接の接合力によって、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造方法において、

前記鋳型中にセラミックス部材を保持した状態で、前記鋳型内の雰囲気を置換して酸素濃度を所定値以下にする鋳型雰囲気置換工程と、

該工程後に前記鋳型を予熱する予熱工程と、

該工程後に前記鋳型内の温度を注湯温度に維持し、該鋳型内に前記金属の溶湯を該鋳型内を満たしていくように注湯する注湯工程と、

該工程後に前記鋳型内の温度を前記金属の溶湯が凝固し始めて接合作用が発揮される接合温度まで下げて、前記セラミックス部材の表面に金属を接合させる接合工程と、

該工程後に前記鋳型を徐冷する徐冷工程と、

を備えていることを特徴とする金属ーセラミックス複合部材の製造方法。

【請求項２】　前記注湯工程では、前記鋳型として、該鋳型内に金属溶湯を導入する溶湯導入口と、前記セラミックス部材を保持すると共に該セラミックス部材の表面と鋳型内壁との間に所定の空隙を確保する接合部とを有し、かつ前記溶湯導入口から接合部にいたる経路の途中に前記金属溶湯表面に形成された酸化被膜を除去する狭隘部を有するものを用いて注湯を行い、

前記接合部に、狭隘部によって酸化被膜が除去された後の金属溶湯を供給することを特徴とする請求項１記載の金属ーセラミックス複合部材の製造方法。

【請求項３】　前記鋳型雰囲気置換工程において、酸素濃度を１％以下にすることを特徴とする請求項１または２記載の金属ーセラミックス複合部材の製造方法。

【請求項４】　前記注湯工程において、注湯温度を７００～８００℃とすることを特徴とする請求項１～３のいずれかに記載の金属ーセラミックス複合部材の製造方法。

【請求項５】　前記接合工程において、接合温度を５５０～７５０℃とすることを特徴とする請求項１～４のいずれかに記載の金属ーセラミックス複合部材の製造方法。

【請求項６】　前記接合工程において前記鋳型内の温度を接合温度まで下げる操作を、前記鋳型底部から上部に向けて段階的に温度が下がるように行うことを特徴とする請求項１～５のいずれかに記載の金属ーセラミックス複合部材の製造方法。

【請求項７】　前記金属が、アルミニウムまたはアルミニウムを主成分とする合金であることを特徴とする請求項１～６のいずれかに記載の金属ーセラミックス複合部材の製造方法。

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【請求項８】　前記セラミックス部材が、アルミニウムの酸化物、窒化物、炭化物、珪素の酸化物、窒化物、炭化物のいずれかであることを特徴とする請求項１～７のいずれかに記載の金属ーセラミックス複合部材の製造方法。

【請求項９】　鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を前記セラミックス部材の表面に接触するように注入して冷却固化させることにより、セラミックスと金属との互いの界面での直接の接合力によって、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造装置において、

前記鋳型中にセラミックス部材を保持した状態で前記鋳型内の雰囲気を置換して酸素濃度を所定値以下にする雰囲気置換手段を有する鋳型雰囲気置換部と、

該鋳型雰囲気置換部において鋳型雰囲気置換を行った後の鋳型を予熱する温度制御手段を有する予熱部と、

該予熱部で予熱した鋳型内の温度を注湯温度に維持する温度制御手段と、該鋳型内に前記金属溶湯を該鋳型内を満たしていくように注湯する注湯手段とを有する注湯部と、

該注湯部で注湯された鋳型内の温度を前記金属溶湯が凝固し始めて接合作用が発揮される接合温度まで下げて前記セラミックスに金属を接合させる冷却接合部と、

前記鋳型を徐冷する徐冷部とを備えていることを特徴とする金属ーセラミックス複合部材の製造装置。

【請求項１０】　前記鋳型雰囲気置換部が、前記鋳型内雰囲気を不活性ガス雰囲気に置換することを特徴とする請求項９記載の金属ーセラミックス複合部材の製造装置。

【請求項１１】　前記冷却部が、前記鋳型を側方から加熱する加熱手段と、前記鋳型を底部から冷却する冷却手段とを有するものであることを特徴とする請求項９または１０記載の金属ーセラミックス複合部材の製造装置。

【請求項１２】　鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を前記セラミックス部材の表面に接触するように注入して冷却固化させることにより、セラミックスと金属との互いの界面での直接の接合力によって、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造方法に用いる製造用鋳型において、

鋳型内に金属溶湯を導入する溶湯導入口と、

前記セラミックス部材を保持すると共に該セラミックス部材の表面と鋳型内壁との間に所定の空隙を確保する接合部と、

前記溶湯導入口から接合部に金属溶湯を導く溶湯通路と、

該溶湯通路のいずれかの場所に設けられて金属溶湯表面に形成された酸化被膜を除去する狭隘部と、

前記接合部に設けられたガス抜き孔とを有し、

前記溶湯導入口から鋳型内に金属溶湯を導入して前記接合部に供給するとき、該金属溶湯が該鋳型内を満たしていくように、前記接合部及び溶湯通路を構成したことを特徴とする金属ーセラミックス複合部材の製造用鋳型。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、セラミックスと金属とが互いの界面での直接の接合力により強固に接合された金属ーセラミックス複合部材の製造方法、製造装置、並びに製造用鋳型に関するものである。

【０００２】

【従来の技術】セラミックスの化学安定性、高融点、絶縁性、高硬度、比較的に高い熱伝導性等の特性と、金属の高強度、高靭性、易加工性、導電性等の特性を生かした金属ーセラミックス複合部材は、自動車、電子装置等に広く用いられ、その代表的な例として、自動車ターボチャージャー用のローター、大電力電子素子実装用の金属ーセラミックス複合基板及びパッケージが挙げられる。

【０００３】上記金属ーセラミックス複合部材の主な製造方法としては、接着、メッキ、メタライズ、溶射、鋳ぐるみ、ろう接法、ＤＢＣ法が公知であるが、金属ーセラミックス複合基板に関しては、近年コスト上の問題から、アルミナ基板を用いるＤＢＣ法や窒化アルミニウム基板を用いる金属活性ろう接合法により、大部分の金属ーセラミックス複合基板が製造されている。

【０００４】しかしながら、従来法においては、金属をアルミナ基板に直接接合する方法としては、銅板を直接接合するＤＢＣ法が公知であるが、アルミニウムを直接接合する方法は今まで知られていなかった。

【０００５】本出願人は先に、セラミックス部材に金属板としてのアルミニウムを直接接合する装置として、特開平８－１９８６２９号公報に「金属ーセラミックス複合部材の製造装置」を提案した。

【０００６】この装置は、セラミックス部材を連続的に供給するための搬送手段と、搬送されたセラミックス部材を予熱する予熱部と、予熱されたセラミックス部材を坩堝内の金属溶湯中を通過させてセラミックス部材の周囲面の少なくとも一部分に金属を接合する接合部と、該接合されたセラミックス部材を徐冷して金属を凝固させ、金属ーセラミックス複合部材となる冷却部とを主要部となすものであり、優れた特性を有する金属ーセラミックス複合部材を大量に製造することが可能である。

【０００７】

【発明が解決しようとする課題】ところで、セラミックス部材に薄板状の金属を接合する場合において、最近、この薄板の厚さの均一性を極めて厳しく管理する要請がなされる場合がみられるが、そのような要請に対しては上記装置では必ずしも十分に対応できない場合があった。また、回路面と放熱面との厚さを変えることにより放熱特性を向上させるセラミックス複合基板の開発もなされているが、上記の連続製造装置では接合後の複合基板を真っ直ぐに引き抜くことは高度な技術を必要とした。

【０００８】すなわち、上記従来の装置は、セラミックス部材を水平方向（横方向）に連続的に供給して坩堝内に通過させる構造である。したがって、板状のセラミックス部材の表裏の２面に金属を接合させる場合、その部材両面に金属溶湯が接触しながら移動して冷却部において接合する。

【０００９】しかしながら、接合された金属の上下面の厚みが異なるセラミックス複合基板の場合は、先端をピンチロールで水平に引っ張っているにもかかわらず、接合された金属面の厚い方向に曲がる傾向のある場合があることが判明し、このことにより連続的な製造を円滑に行うのに高度な技術を必要とした。

【００１０】本発明は、上述の背景のもとでなされたものであり、特に優れた接合特性を有する多種多様の金属ーセラミックス複合部材を、低コストで製造することを可能にするための製造方法、製造装置、並びに製造用鋳型を提供することを目的とする。

【００１１】

【課題を解決するための手段】請求項１の発明の製造方法は、鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を前記セラミックス部材の表面に接触するように注入して冷却固化させることにより、セラミックスと金属との互いの界面での直接の接合力によって、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造方法において、鋳型中にセラミックス部材を保持した状態で、鋳型内の雰囲気を置換して酸素濃度を所定値以下にする鋳型雰囲気置換工程と、該工程後に鋳型を予熱する予熱工程と、該工程後に鋳型内の温度を注湯温度に維持し、鋳型内に金属の溶湯を該鋳型内を満たしていくように注湯する注湯工程と、該工程後に鋳型内の温度を金属の溶湯が凝固し始めて接合作用が発揮される接合温度まで下げて、セラミックス部材の表面に金属を接合させる接合工程と、該工程後に鋳型を徐冷する徐冷工程とを備えていることを特徴とする。

【００１２】請求項２の発明の製造方法は、請求項１において、前記注湯工程で、前記鋳型として、該鋳型内に金属溶湯を導入する溶湯導入口と、セラミックス部材を保持すると共にセラミックス部材の表面と鋳型内壁との間に所定の空隙を確保する接合部とを有し、かつ溶湯導入口から接合部にいたる経路の途中に金属溶湯表面に形成された酸化被膜を除去する狭隘部を有するものを用いて注湯を行い、前記接合部に、狭隘部によって酸化被膜が除去された後の金属溶湯を供給することを特徴とする。

【００１３】請求項３の発明の製造方法は、請求項１ま

たは２において、前記鋳型雰囲気置換工程にて、酸素濃度を１％以下にすることを特徴とする。

【００１４】請求項４の発明の製造方法は、請求項１～３のいずれかにおいて、前記注湯工程における注湯温度が７００～８００℃であることを特徴とする。

【００１５】請求項５の発明の製造方法は、請求項１～４のいずれかにおいて、前記接合工程における接合温度が５５０～７５０℃であることを特徴とする。

【００１６】請求項６の発明の製造方法は、請求項１～５のいずれかにおいて、前記接合工程において鋳型内の温度を接合温度まで下げる操作を、鋳型底部から上部に向けて段階的に温度が下がるように行うことを特徴とする。

【００１７】請求項７の発明の製造方法は、請求項１～６のいずれかにおいて、前記金属がアルミニウムまたはアルミニウムを主成分とする合金であることを特徴とする。

【００１８】請求項８の発明の製造方法は、請求項１～７のいずれかにおいて、前記セラミックス部材がアルミニウムの酸化物、窒化物、炭化物、珪素の酸化物、窒化物、炭化物のいずれかであることを特徴とする。

【００１９】請求項９の発明の製造装置は、鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を前記セラミックス部材の表面に接触するように注入して冷却固化させることにより、セラミックスと金属との互いの界面での直接の接合力によって、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造装置において、鋳型中にセラミックス部材を保持した状態で鋳型内の雰囲気を置換して酸素濃度を所定値以下にする雰囲気置換手段を有する鋳型雰囲気置換部と、該鋳型雰囲気置換部において鋳型雰囲気置換を行った後の鋳型を予熱する温度制御手段を有する予熱部と、該予熱部で予熱した鋳型内の温度を注湯温度に維持する温度制御手段と鋳型内に金属溶湯を該鋳型内を満たしていくように注湯する注湯手段とを有する注湯部と、該注湯部で注湯された鋳型内の温度を金属溶湯が凝固し始めて接合作用が発揮される接合温度まで下げてセラミックスに金属を接合させる冷却接合部と、前記鋳型を徐冷する徐冷部とを備えることを特徴とする。

【００２０】請求項１０の発明の製造装置は、請求項９において、前記鋳型雰囲気置換部が鋳型内雰囲気を不活性ガス雰囲気に置換することを特徴とする。

【００２１】請求項１１の発明の製造装置は、請求項９または１０において、前記冷却部が、鋳型を側方から加熱する加熱手段と、鋳型を底部から冷却する冷却手段とを有するものであることを特徴とする。

【００２２】請求項１２の発明の製造用鋳型は、鋳型中にセラミックス部材を保持し、該鋳型中に、接合すべき金属の溶湯を前記セラミックス部材の表面に接触するように注入して冷却固化させることにより、セラミックスと金属との互いの界面での直接の接合力によって、セラミックス部材の表面に金属を接合する金属ーセラミックス複合部材の製造方法に用いる製造用鋳型において、鋳型内に金属溶湯を導入する溶湯導入口と、前記セラミックス部材を保持すると共に該セラミックス部材の表面と鋳型内壁との間に所定の空隙を確保する接合部と、前記溶湯導入口から接合部に金属溶湯を導く溶湯通路と、該溶湯通路のいずれかの場所に設けられて金属溶湯表面に形成された酸化被膜を除去する狭隘部と、前記接合部に設けられたガス抜き孔とを有し、前記溶湯導入口から鋳型内に金属溶湯を導入して前記接合部に供給するとき、該金属溶湯が該鋳型内を満たしていくように、前記接合部及び溶湯通路を構成したことを特徴とする。

【００２３】上述の構成によれば、鋳型中にセラミックス部材を保持した状態で鋳型内の雰囲気を置換して酸素濃度を所定値以下にする鋳型雰囲気置換工程を行い、次に鋳型を予熱する予熱工程を行い、次に鋳型内の温度を注湯温度に維持し、鋳型内に金属の溶湯を、セラミックス表面に金属溶湯が接触しつつ一側から他側に向けて移動して順次鋳型内を満たしていくように注湯する注湯工程を行い、次に鋳型内の温度を金属の溶湯が凝固し始めて接合作用が発揮される接合温度まで下げて、セラミックス部材の表面に金属を接合させる接合工程を行い、次に鋳型を徐冷する徐冷工程を行うようにしたことによって、セラミックスと金属との界面での直接の接合力を極めて強固にすることができると共に、例えば、セラミックス基板の両面に、回路面としての金属薄板と放熱面としての金属薄板とを接合する場合のように、両面に互いに厚みの異なる金属薄板を接合する場合にも、鋳型の精度を適切なものにすることによって、容易に高精度で均一な厚さの金属薄板を接合することができる。しかも、予熱工程や注湯工程及び接合工程において、各々適切な温度に設定するようにしているので、セラミックス部材に過大な熱的応力が加わることがなく、したがって熱応力によって破損するおそれもない。

【００２４】さらに、鋳型として、鋳型内に金属溶湯を導入する溶湯導入口と、セラミックス部材を保持すると共にセラミックス部材の表面と鋳型内壁との間に所定の空隙を確保する接合部とを有し、溶湯導入口から接合部にいたる経路のいずれかの場所に金属溶湯表面に形成された酸化被膜を除去する狭隘部を有するものを用いて注湯工程を行うようにして、接合部には酸化皮膜が除去された純粋な金属溶湯のみが供給されるようにすることによって、より強固な接合力を得ることを可能にしている。

【００２５】本発明は、金属溶湯をセラミックス表面に接触させても接合力は得られないという従来の常識に対し、特定条件のもとで接触させて固化すると接合力が得られるという本発明者らによる発見に基づくものである。この接合力が得られるメカニズムについては未だ十

分に解明されていないが、上記特定の条件は、本発明者らによって試行錯誤的に得られている。

【００２６】すなわち、接合の際に接合部位及びその周囲の雰囲気の酸素濃度ができるだけ低いほうが強固な接合力を得る上で有利であること、セラミックス表面と金属溶湯とを相対移動させて両者をこするようにして接触させて接合させることが、より強固な接合力を得る上で有利であること、接触させる金属溶湯は酸化被膜が取り除かれていることが、強固な接合力を得る上で有利であること、等である。

【００２７】本発明で使用する金属としては、アルミニウム又はアルミニウムを主成分とする合金等を用いることができる。また、本発明で使用するセラミックス部材としては、アルミニウムや珪素の酸化物、窒化物、炭化物等を用いることができる。

【００２８】これらの組み合わせによれば、例えば、セラミックス基板の両面に回路面たる金属薄板と放熱面たる金属薄板とを接合したパワーモジュール用基板を構成した場合、パワーモジュールの発熱によるアルミニウムとセラミックス基板との熱膨張差は比較的大きいが、アルミニウムの強度が低いため、熱膨脹差による接合劣化が少ないものを得ることができる。

【００２９】

【発明の実施の形態】以下、本発明の実施形態を図面に基づいて説明する。図１は金属ーセラミックス複合部材の製造装置の構成を示す図、図２～図６は鋳型の構成図であり、図２は製造用鋳型の斜視図、図３は図２のＩＩＩーＩＩＩ矢視方向に見た鋳型の分解平面図、図４は図２のＩＶーＩＶ矢視図、図５は図２のＶーＶ矢視断面図、図６は図２のＶＩーＶＩ矢視断面図である。

【００３０】本製造装置は、特殊形状の鋳型１０を用い、この鋳型１０の内部にセラミックス基板Ｋ〔図３、図６（ｂ）参照〕を保持して、その周囲に金属溶湯を接触させることにより、金属ーセラミックス複合部材を製造するものである。この製造装置は、図１に示すように、鋳型１０内の雰囲気を酸素濃度１％以下の不活性ガス雰囲気条件に調整する雰囲気置換部（雰囲気置換手段）１と、雰囲気置換部１で雰囲気を置換した後の鋳型１０を予熱する予熱部２と、該予熱部２で予熱した鋳型１０内の温度を注湯温度に維持し、その状態で鋳型１０内に金属溶湯を、セラミックス部材の表面に金属溶湯が接触しつつ一側から他側に向けて移動して順次鋳型内を満たしていくように注湯する注湯部３と、該注湯部３で注湯された鋳型１０内の温度を金属溶湯が凝固し始めて接合作用が発揮される接合温度まで下げてセラミックスに金属を接合させる冷却接合部４と、前記鋳型１０を徐冷する徐冷部５とから構成されている。

【００３１】これら雰囲気置換部１、予熱部２、注湯部３、冷却接合部４、徐冷部５は、水平方向に直列に並んでおり、雰囲気置換部１と予熱部２との間、注湯部３と冷却部４の間、冷却部４と徐冷部５との間には、遮蔽用のシャッタ６Ａ、６Ｂ、６Ｃが設けられている。また、予熱部２、注湯部３、冷却部４の側壁には、加熱手段及び温度制御手段としてのヒータ８Ａ、８Ｂ、８Ｃが設けられ、室内に収容した鋳型１０の温度を適切に制御できるようになっている。特に、冷却接合部５には、鋳型１０を底部から冷却できるよう冷却手段としての水冷ジャケット９が配されている。なお、図１の注湯部３において、鋳型１０に取り付けられている符号２１で示すものはリニアドモータ、２２は黒鉛製ピストンである。これらは、注湯手段に相当する。

【００３２】次に黒鉛で作製した鋳型１０について説明する。図２、図３に示すように、ここで用いる鋳型１０は、表側と裏側の鋳型板１０Ａ、１０Ａと中央の鋳型板１０Ｂを３枚合わせにして結合し、一度に４枚の回路基板（金属ーセラミックス複合部材）を作れるようにしたものである。図４は表側及び裏側の鋳型板１０Ａの内壁面の形状、図５は中央鋳型板１０Ｂの両壁面の形状を示している。

【００３３】これら鋳型板１０Ａ、１０Ｂは、所定形状の凹所１１Ａ、１１Ｂ、１３Ａ、１３Ｂ、１４Ａ、１４Ｂを有しており、鋳型１０として組み合わせられることにより、溶湯導入口としての注入筒固定部１１、溶湯導入通路１３、接合部１４を形成している。溶湯注入筒固定部１１は鋳型１０の中央部に配置され、その下部より枝分かれするように溶湯導入通路１３が水平方向に展開され、各溶湯導入通路１３の先端に連通するように各接合部１４が設けられている。接合部１４としての空間は、中央鋳型板１０Ｂの表裏両面に形成されると共に、溶湯注入筒固定部１１を挟んで左右対称に２個形成されている。従って、全部で４個ある。

【００３４】また、３枚の鋳型板１０Ａ、１０Ａ、１０Ｂで構成される鋳型１０には、溶湯注入筒固定部１１と溶湯導入通路１３との境界に位置させて両者を連通する狭隘部１２が形成され、接合部１４に中央領域が重なる形でセラミックス部材固定用凹部１６が形成され、接合部１４の上部に連通するようにガス抜き孔１５が形成されている。セラミックス部材固定用凹部１６と接合部１４の関係は、図６（ｂ）に示すように、セラミックス部材固定用凹部１６にセラミックス部材Ｋを嵌めた状態で鋳型１０を閉じたとき、接合部１４の内壁面と、セラミックス部材Ｋとの間に所定の空隙２９を確保できるような関係となっている。

【００３５】また、狭隘部１２は、溶湯注入筒固定部（溶湯導入口に相当）１１より注入された金属溶湯表面の酸化被膜を除去する箇所であり、酸化被膜の通過を許さない程度の口径（例えば、１ｍｍ以下、好ましくは０．８ｍｍ以下）に形成されている。狭隘部１２によって酸化被膜が除去された後の金属溶湯は、溶湯導入通路１３の垂直な空間に入り、そこから溶湯導入通路１３の

水平な空間を通って接合部１４の底部に導入され、接合部１４の底部から上方に向かって移動して行き、その間にセラミックス部材固定用凹部１６に保持されたセラミックス部材Ｋの表面に接触する。従って、金属溶湯は、溶湯注入筒固定部１１に注入された後、一旦下方に下がってから、上方に移動しながらセラミックス部材Ｋに接触して行くように、溶湯の経路が構成されている。

【００３６】なお、鋳型板１０Ａ、１０Ａ、１０Ｂの外周部には、互いに結合する際に嵌合して鋳型板１０Ａ、１０Ａ、１０Ｂ相互を位置決めする凹凸部１９Ａ、１９Ｂが設けられている。

【００３７】次に上記の鋳型１０及び製造装置を用いて目的の複合部材を作る方法について説明する。ここでは、まずセラミックス部材Ｋとして、６２ｍｍ×１１２ｍｍ×０．６３５ｍｍのアルミナセラミックス基板を４枚用意し、これら基板Ｋを、図３に示すように、表裏の鋳型板１０Ａ、１０Ｂのセラミックス部材固定用凹部１６に嵌めて、表裏の鋳型板１０Ａ、１０Ａを中央鋳型板１０Ｂと合体することにより、一体化した鋳型１０を作る。次いで、この鋳型１０を雰囲気置換部１に設置し、雰囲気置換部１の炉内に窒素ガスを流入させることにより、鋳型１０内の酸素濃度を１％以下、好ましくは０～５００ｐｐｍとする（雰囲気置換工程）。

【００３８】次いで、鋳型１０を予熱部２に移動させ、この予熱部２内のヒータ８Ａにより鋳型１０を室温から８００℃まで１時間で昇温する（予熱工程）。この場合、鋳型１０内のセラミックス部材Ｋが割れないように昇温しなければならない。

【００３９】次いで、予熱した鋳型１０を注入部３に移動させ、鋳型１０の上部の溶湯注入筒固定部１１に黒鉛製ピストン２２及びリニアドモータ１１をセットする。そして、アルミニウム溶湯（金属溶湯）を鋳型１０に注入した状態で、リニアドモータ２１で黒鉛製ピストン２２を加圧することにより、アルミニウム溶湯を鋳型１０内に押し込み（押し込み力は７０ｋｇＭＡＸ）、狭隘部１２を通過させることにより、アルミニウムの表面酸化膜を破った後の純粋なアルミニウム溶湯のみを狭隘部１２より下の溶湯導入通路１３に供給する。アルミニウム溶湯がセラミック基板上を１０００ｍｍ／ｍｉｎ以下の速度で移動するよう鋳型１内にアルミニウム溶湯を注入するのがよい。

【００４０】このように、溶湯導入通路１３にアルミニウム溶湯を押し込んで行くと、アルミニウム溶湯は、溶湯導入通路１３から接合部１４の底部に導入され、セラミックス部材箇定用凹部１６に固定されたセラミックス基板の両面を挟むように上って行き、接合部１４の上端（溶湯溜め部）に到達する（注湯工程）。このうちの一部がガス抜き孔１５から抜け出たところで、リニアドモータ２１の作動を止める。

【００４１】この注湯工程の際に、注湯部３の炉内温度を、ヒータ８Ｂで７００～８５０℃に調整しておく。これは、アルミニウムの融点が６６０℃であることから、７００℃以下では湯流れ性が悪くなり、逆に８５０℃以上だと鋳型離形材と反応して鋳型離れが悪くなるからである。

【００４２】上記の注湯工程を完了したら、鋳型１０を冷却接合部４に移動させ、冷却接合部４において、両壁のヒータ８Ｃで加熱しながら、下部の水冷ジヤケット９で冷却し、鋳型１０の下部から高さ方向に１ｃｍ当たり３～５℃の温度勾配をかけながら、６００℃まで、３０分かけて徐冷し、アルミニウムをセラミックス基板に接合させる（接合工程）。

【００４３】次に鋳型１０を徐冷部５に取り出して室温温度近くまで徐令（徐冷工程）した後、鋳型１０を外に出し、鋳型１０から４枚のアルミニウムーアルミナセラミックス複合部材を取り出して作業を完了する。

【００４４】このようにして得られたアルミニウムーアルミナセラミックス複合部材は、アルミニウム表面に引け巣等の無い均一な面を示していた。

【００４５】なお、セラミックス部材として、窒化アルミニウム部材や窒化珪素部材を用いて同様の処理を行った場合も、同様に引け巣等の無い均一な面を示す複合部材が得られた。

【００４６】

【発明の効果】以上説明したように、本発明によれば、セラミックスと金属との界面での直接の接合力を極めて強固にすることができると共に、引け巣等のない複合基板を歩留まりよく製造することができる。従って、例えばセラミックス基板の両面に、回路面としての金属薄板と放熱面としての金属薄板とを接合する場合のように、両面に互いに厚みの異なる金属薄板を接合する場合にも、鋳型の精度を適切なものにすることによって、容易に高精度で均一な厚さの金属薄板を接合することができる。また、予熱工程や注湯工程及び接合工程等の各工程において鋳型を適切な温度に設定することにより、セラミックス部材に過大な熱応力が加わるのを避けることができ、熱応力によって破損するおそれを無くすことができる。また、鋳型の内部に酸化被膜を取り除く狭隘部を設け、酸化皮膜が除去された純粋な金属溶湯のみが接合部に供給されるようにすれば、より強固な接合力を得ることができる。よって、優れた接合特性を有する多種多様の金属ーセラミックス複合部材を低コストに製造することが可能となる。

【図面の簡単な説明】

【図１】本発明の金属ーセラミックス複合部材の製造装置の主要部の構成を示す概略断面図である。

【図２】本発明の金属ーセラミックス複合部材の製造装置に用いる鋳型の概略斜視図である。

【図３】図２のＩＩＩーＩＩＩ矢視方向からみた鋳型の分解平面図である。

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【図４】図２のＩＶ－ＩＶ矢視図である。
【図５】図２のＶ－Ｖ矢視図である。
【図６】（ａ）は図２のＶＩａ－ＶＩａ矢視断面図、（ｂ）は図２のＶＩｂ－ＶＩｂ矢視断面図である。
【符号の説明】
１　雰囲気置換部
２　予熱部
３　注入部
４　冷却部
５　徐冷部

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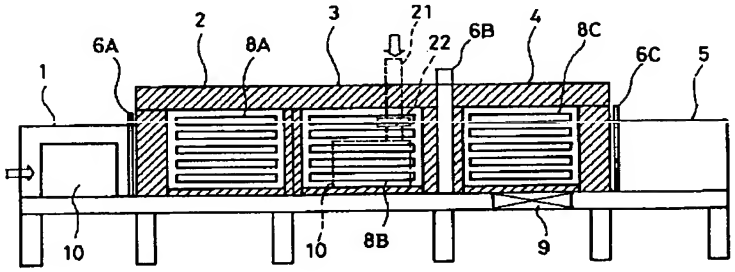
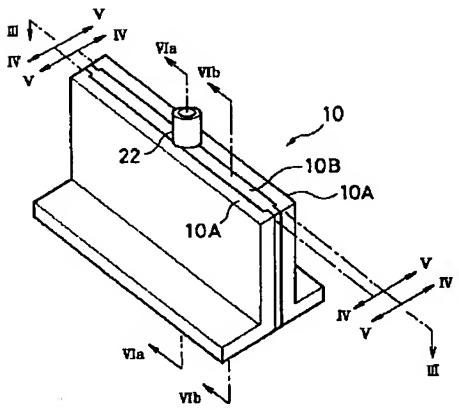
＊８Ａ，８Ｂ，８Ｃ　ヒータ（加熱手段、温度制御手段）
９　水冷ジャケット（冷却手段）
１０　鋳型
１１　溶湯導入口
１２　狭隘部
１３　金属溶湯通路
１４　接合部
１５　ガス抜き孔
Ｋ　セラミックス部材
＊10

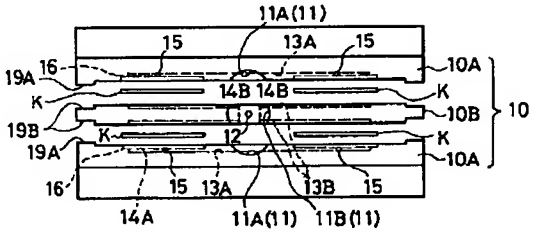
【図１】



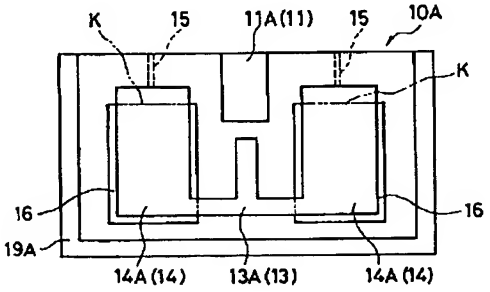
【図２】



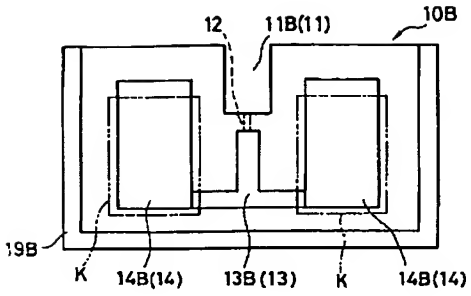
【図３】



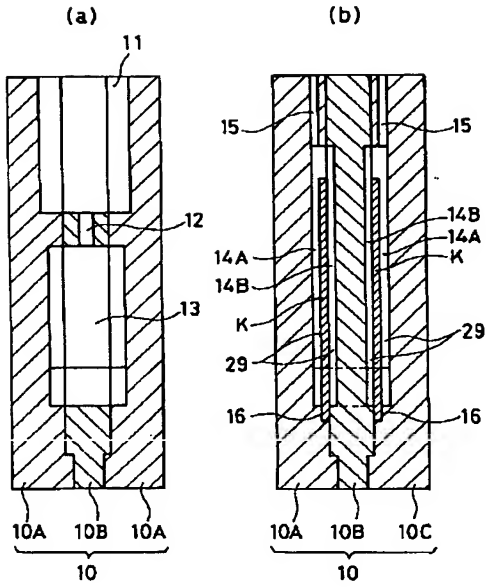
【図４】



【図５】


12
11B(11)
10B
19B
K
14B(14)
13B(13)
K
14B(14)

【図６】


(a)
(b)
11
12
13
15
15
14B
14A
K
14A
14B
K
29
29
16
16
10A
10B
10A
10A
10B
10C
10
10